EFFECT OF THE ADHESION BETWEEN CARBON FIBERS WITH NON-CIRCULAR CROSS SECTIONS AND SiC COATING ON THEIR MECHANICAL PROPERTIES AND OXIDATION DURABILITY

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INTRODUCTION

Carbon fibers with non-circular cross sections are promising reinforcing materials for producing of advanced composites[1]. However, for high temperature applications a protective barrier layer is needed to inhibit the oxidation of carbon fibers. Silicon carbide coatings are known to be of technological interest because of their many excellent properties.

Chemical vapor deposition (CVD) is the only technique which can produce thin films on the fiber surface. This is a process whereby a stable deposit nucleates and grows on the heated substrate by thermal dissociation or chemical reaction of gaseous precursors[2]. In principle, it is possible to tailor the stoichiometry, morphology, crystal structure and adherence of the deposit by careful choice of the deposition parameters such as deposition temperature, total pressure and composition of the carrier gas.

This paper presents the results of the effect of the adhesion between carbon fibers and SiC coating on their tensile strength and oxidation durability.

EXPERIMENTAL

The experiments were carried out with mesophase pitch-based carbon fibers with ribbon and C-shaped cross sections, prepared at Clemson University and at Chungnam National University, respectively.

The deposition of silicon carbide on the carbon fibers was performed by chemical vapour deposition (CVD) in a hot wall reactor under reduced pressure (250 mbar) at 850°C. Methyltrichlorosilane (MTS) was chosen as an educt because it contains 1:1 ratio of silicon to carbon; therefore, it is the most common and useful reactant. As carrier gases, hydrogen or hydrogen / argon mixtures were used.

The uncoated as well as the coated carbon fibers with non-circular cross sections were characterized by their tensile strength measured in a 30 mm monofilament test. Their oxidation behavior was measured in a thermal balance under static conditions and expressed as the relative mass loss during heating in air at 700°C. The adhesion between the SiC films and the carbon fibers was evaluated by scanning electron microscopy (SEM).

RESULTS AND DISCUSSION

Fig. 1 shows the microphotographs of carbon fibers with ribbon and C-shaped cross sections coated with a appr. 100 nm SiC film using hydrogen (a, c) or argon / hydrogen (1:1) mixture (b, d) as a carrier gas.

SEM-investigations reveal a sufficient adhesion only when the decomposition was performed in **hydrogen** atmosphere. Contrary to this observation, a spalling of parts of the SiC layer was detected if a mixture of hydrogen and argon (1:1) has been used as a carrier gas. This is obviously due to the excess carbon co-deposed under these conditions in the deposition layer[3].

Also the tensile strength of the coated carbon fibers is strongly influenced by the adhesion between fiber and coating. As shown in Tab. 1, poor adhesion, causes in all cases, a stronger decrease of the tensile strength, in comparison with good adherent films.

The effect of the SiC film adherence, as well as the profile of the fiber's cross section, on the oxidation durability of the coated fibers is shown in Fig. 2. Uncoated C-shaped carbon fibers seem to be more sensitive to oxidation than the ribbon-shaped ones. As illustrated in Fig. 2, an adherent thin SiC film provides an effective oxidation protection of the carbon fibers. Poor fiber/coating adhesion, on the contrary, makes the oxygen diffusion and, therefore, the attack of the carbon surface easier.

CONCLUSIONS

Good adhesion between carbon fibers and thin SiC films are required to obtain a good oxidation protection without a significant reduction of their tensile strength.

REFERENCES

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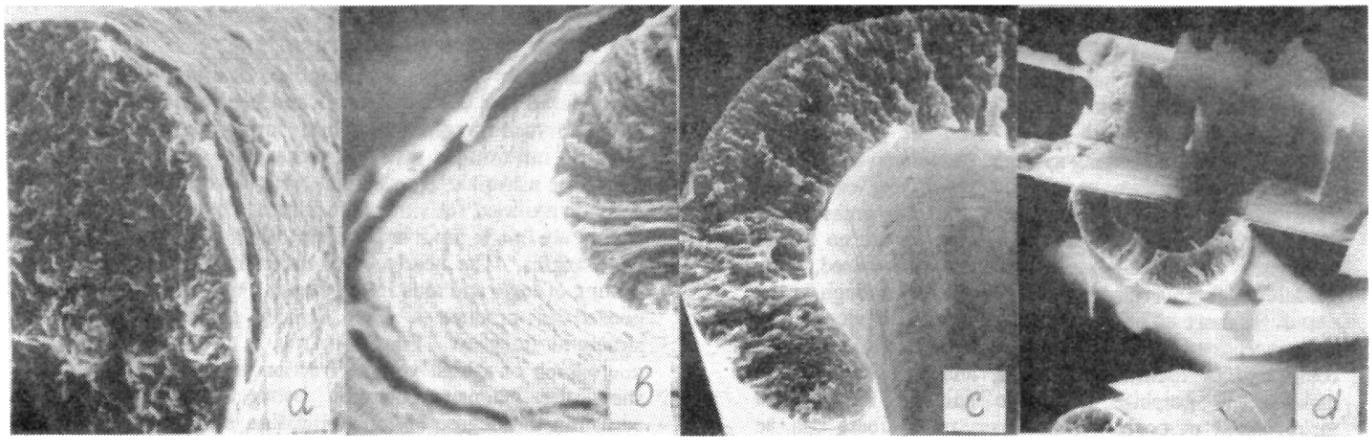

Figure 1- SiC coating on ribbon- and C-shaped carbon fibers
Carriergas: hydrogen (a, c) or argon/hydrogen(1:1)-b,d

Carbon Fiber	Tensile Strength, σ [Mpa]	Relative Tensile Strength, $\sigma / \sigma_{uncoated}$
Ribbon Shaped, uncoated	1564 ± 343	1,00
Ribbon, SiC coated (good adhesion)	1422 ± 294	0,909
Ribbon, SiC coated (poor adhesion)	1279 ± 268	0,818
C-Shaped, uncoated	988 ± 217	1,00
C-Shaped, SiC coated (good adhesion)	896 ± 206	0,907
C-Shaped, SiC coated (poor adhesion)	811 ± 170	0,818

Table 1: Effect of the adhesion between carbon fibers and SiC coating on the tensile strength

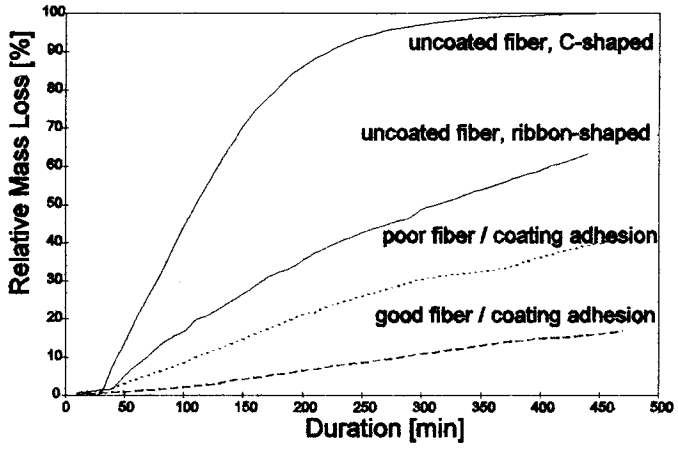

Fig. 2 Effect of the adhesion between carbon fiber and SiC coating on the oxidation durability at 700°C in air